ERDC/CERL SR-07-5

Construction Engineering ResearchLaboratory

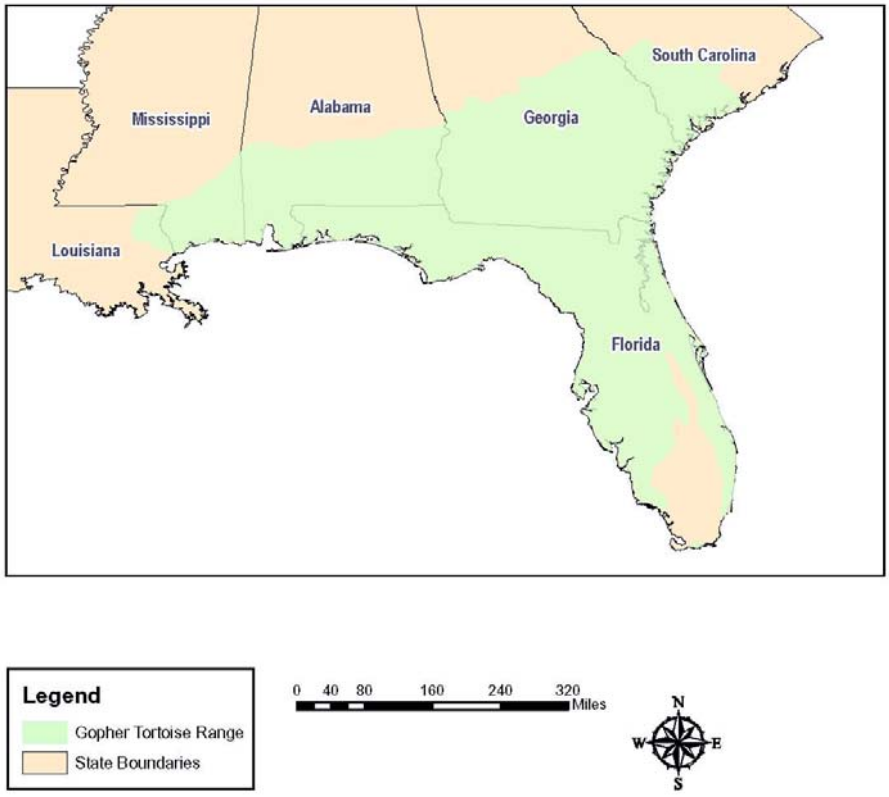
US Army Corps of Engineers®
Engineer Research and Development Center

Existing Geospatial Knowledge of Gopher Tortoise Population and Abundance

William D. Meyer, Harold E. Balbach, and Jason T. Berner

May 2007

Gopher Tortoise (Gopherus polyphemus)
Regional Distribution Map



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Final report

Prepared for U.S. Army Corps of Engineers
Washington, DC 20314-1000

Under Work Unit K9853F

Abstract: A number of key Army installations in the southeastern United States support numerous at-risk species. Many of these species have the potential to cause severe training restrictions in the future. To avoid the loss of training capacity, a proactive strategy for species conservation across the range must be developed.

The gopher tortoise (*Gopherus polyphemus*) may be the most prominent and most widely distributed of these at-risk species in the Southeast. In the case of the tortoise, a proactive strategy will require a basic understanding of its current abundance and distribution, better understanding of its habitat requirements, development of population viability analysis methods, agreement among regulators and land managers on population goals, and methods to efficiently monitor gopher tortoise populations over time with regard to the established population goals.

Data on the gopher tortoise were collected from academic, national, state, and local sources. All data were captured in tabular or GIS vector and raster formats. Data received at the Construction Engineering Research Laboratory were entered into spatial data layers as appropriate, and appended with quality-checked metadata to describe the dataset. This dataset will be available on CD or DVD for distribution to the public.

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Preface

This study was conducted for the Construction Engineering Research Laboratory (ERDC-CERL) under "Training Lands Management-Characterization, Analysis, and Mitigation," under program element P622720, "Army Environmental Quality Technology"; Work Unit K9853F, "Gopher Tortoise Candidate Conservation Plan. TASK-1 Assimilation of Existing Geospatial Knowledge on Gopher Tortoise Population Abundance and Distribution." The CERL technical monitor was Dr. William Severinghaus, Technical Director, Sustainable Ranges and Lands.

The Ecological Processes Branch (CN-N) of the Installations Division (CN), Construction Engineering Research Laboratory (CERL), performed the work. The CERL Principal Investigators were William D. Meyer and Dr. Harold Balbach. Dr. Timothy Hayden is Program Manager of the Threatened and Endangered Species Program, Alan Anderson is Chief, CN-N, and Dr. John T. Bandy is Chief, CN. The Deputy Director of CERL is Dr. Kirankumar V. Topudurti, and the Director of CERL is Dr. Ilker R. Adiguzel.

CERL is an element of the U.S. Army Engineer Research and Development Center (ERDC), U.S. Army Corps of Engineers. The Commander and Executive Director of ERDC is COL Richard B. Jenkins, and the Director of ERDC is Dr. James R. Houston.

1 Introduction

A number of key Army installations in the southeastern United States support numerous at-risk species. Many of these species are listed at various risk levels by the states, and some are federally listed as threatened. Although these species are not currently causing significant training restrictions, they clearly have the potential to cause severe training restrictions in the future, especially if they progress to being listed. To avoid the loss of training capacity, a proactive strategy for species conservation across the range must be developed before such crises develop.

The gopher tortoise (*Gopherus polyphemus*) may be the most prominent and most widely distributed of these at-risk species in the Southeast. In the case of the tortoise, a proactive strategy will require a basic understanding of its current abundance and distribution, better understanding of its habitat requirements, development of population viability analysis methods, agreement among regulators and land managers on population goals, and methods to efficiently monitor gopher tortoise populations over time with regard to the established population goals.

Species background and significance to the Army

Gopher tortoises occur naturally in the upland sandy region of the Southeast across portions of six states (Louisiana, Mississippi, Alabama, Georgia, South Carolina, and Florida—see Figure 1). The original distribution was associated with open pine forests, especially the longleaf pine (*Pinus palustris*), where friable soils allowed construction of the tortoise burrows. The tortoise is now restricted at the edges of its distribution in South Carolina and Louisiana to only one or two counties/parishes. Large populations are found in Mississippi, Alabama, Georgia, and Florida. The gopher tortoise is a keystone species within its habitat. More than 330 vertebrate and invertebrate species have been documented as burrow commensals (Burke 1989). Common associates in many parts of the gopher tortoise's range include other rare species such as eastern indigo snake (*Drymarchon couperi*) and gopher frog (*Rana capito*). Sharing portions of its original habitat are the at-risk plant species sandhill chaffhead (*Carphephorus beliidifolius*) and sandhill gay-feather (*Liatris secunda*).

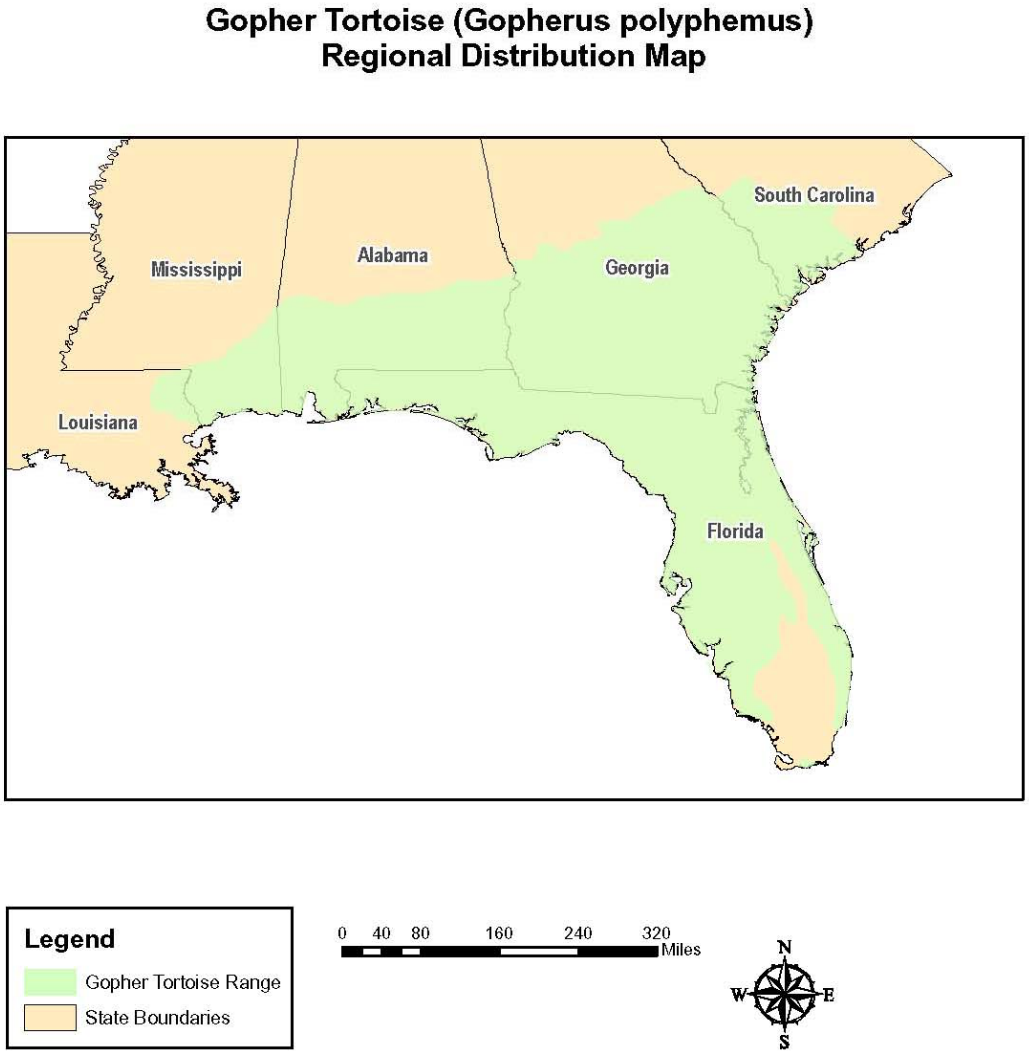

Figure 1. Gopher tortoise regional habitat map.

Populations are declining throughout the species' distribution. Auffenberg and Franz (1982) estimated that in the past 100 years gopher tortoise populations have declined by 80 percent. This significant decline contributed to the species being listed by the U. S. Fish and Wildlife Service (FWS) as "Threatened" in the western portion of the range (Louisiana, Mississippi, and west of the Tombigbee and Mobile Rivers in Alabama; *Federal Register*, July 7, 1987). A petition to list it as threatened in the remainder of the range was received by the U.S. Fish and Wildlife Service

in January 2006 (Save Our Big Scrub, 2006). Throughout their range, exclusion of fire or ineffective burning has transformed open upland habitat into dense mixed hardwood forests that are no longer suitable for gopher tortoises. They now often inhabit disturbed areas that are cleared and maintained as some mix of grasses and forbs, usually through mowing. On military bases, gopher tortoises often locate their burrows in areas that are maintained for training (e.g., firing points, ranges, and margins of airstrips). Military installations support some of largest remaining populations both in the listed and in the unlisted range. In the listed range, Camp Shelby, MS, and the adjoining De Soto National Forest provide habitat for the largest listed population. Installations in the unlisted range hosting gopher tortoise populations include: Fort Rucker, AL; Forts Benning, Stewart, and Gordon, and Moody Air Force Base (AFB) in GA, and Eglin AFB and Camp Blanding, FL. Presence of this species on Department of Defense (DoD) installations is already causing training restrictions (both in the unlisted and listed range), and if listing is extended to the eastern population, training restrictions at such key installations as Fort Benning (which has more than 8,000 recorded gopher tortoises borrows scattered across the installation) could be severe.

For these reasons, it is critical that DoD both understand the effects of its training activities on the gopher tortoise, and partner with other land management entities throughout the region to take necessary actions to preclude listing of the species in the easternmost portion of its range.

Objective

The objective of this effort is to develop an understanding of the current species abundance and geographical distribution to use as a basis for tracking the status of population declines or increases throughout ensuing conservation efforts. The result of this research will provide a consistent data set of information that has been quality checked to achieve the highest possible standard of rigor and currency. The dataset will be available to all who wish to participate in this conservation effort.

Sharing geographic information system (GIS) data between political and managerial boundaries will give a more holistic perspective of conservation management efforts within the eastern range of the gopher tortoise. It is hoped that the approach used to collect and organize this GIS data will enable careful management of the gopher tortoise and other rare, threatened, and/or endangered species within the region. Continued use and

maintenance of the Existing Data database will expand cooperative management efforts and initiate increased exchange of relevant data. Increasing exchange of this data in the future will also prompt the need to better organize information on management efforts and projects. With limited managerial resources, the cooperative use of this regional GIS database for the gopher tortoise will help to increase efficiency and success of management goals and objectives on small and large spatial scales.

Approach

Data were collected from academic, national, state, and local sources. All data were captured in tabular or GIS vector and raster formats. Data received at the U.S. Army Engineer Research and Development Center Construction Engineering Research Laboratory were entered into spatial data layers as appropriate, and appended with quality-checked metadata to describe the dataset. This dataset along with a copy of this report will be available on CD or DVD for distribution to the public.

Mode of technology transfer

This report will be made accessible through the World Wide Web (WWW) at URL: http://www.cecer.army.mil.

The CD or DVD can be acquired with an e-mail request to William D. Meyer at William.D.Meyer@erdc.usace.army.mil.

2 Description of Data

The gopher tortoise GIS database collected during this research contains major information related to the entire home range of the gopher tortoise. Geographic areas identified as significant were the result of a thorough literature review of the species along with interviews of scientists, conservation professionals, and citizen volunteers. Data collection was organized by state and county. Most data collected came from public informational sources. Where available the following types of data were collected:

- Hydrological Units
- Soils
- Ecoregions
- Landcover
- MODIS imagery (Moderate Resolution Imaging Spectroradiometer)
- Digital Orthographic Images
- Gap Analysis Program (GAP), which includes U.S. Geological Survey (USGS) data and National Biological Information Infrastructure National Land Coverage Data (NLCD)
- State GIS database data
- National Elevation Dataset
- Geological
- Gopher Tortoise Habitat Regions
- Military Installations
- Roads
- Railways
- Forests
- Census Data
- Gopher Tortoise Burrow Locations (restricted access)

GIS data were gathered from the following organizations: Natural Resources Conservation Service(NRCS)-U.S. Department of Agriculture (USDA), USGS, George Mason University, National Aeronautics and Space Administration (NASA), U.S. Census Bureau, U.S. Environmental Protection Agency (EPA), State of Alabama Geological Survey GIS, Louisiana GIS Council, Mississippi Automated Resource Information System Technical Center, South Carolina Department of Natural Resources, University of Florida's GeoPlan Center, Florida Fish and Wildlife Conservation Com-

mission, Georgia GIS Clearinghouse, The Nature Conservancy, and the GAP.

Each state and county has varying types of data. All of these data can be viewed from various scales, including regional, state, and county levels. All states within the gopher tortoise eastern range have GIS databases that contain useful data at state and county scales. Also non-government organizations (NGOs) and state universities served as sources of GIS data. Some overlap occurs between state and Federal GIS data files, which may explain redundancy or slight differences in the data. Depending on the area of interest, using federal, state, university, and NGO data, or a combination of sources, may be most helpful.

The first table in the Appendix depicts all of the existing GIS data related to the eastern range of the gopher tortoise. The data are organized based on source of origin: Federal, state, NGO, or university. Following the GIS organizational chart is another table depicting all of the counties within the eastern gopher tortoise range. The last tables are Federal and state data, which organize existing data within the following subtopics: data type, description, source, and date acquired. All GIS data are accompanied by metadata, which have been compiled into ArcCatalog.

3 Methods

All data collected were based on the extent of gopher tortoise habitat defined by the map Gopher Tortoise Regional Habitat (Figure 1). Any physiographic, ecological, and socio-cultural data believed to be relevant to gopher tortoise habitat were collected. Federal GIS databases were reviewed for large-scale information. These data usually included regional, state, and county data. Small-scale data were reviewed from state GIS clearinghouses, NGOs, and universities. State- and county-based data were normally acquired from these sources.

The projected and geographic coordinate systems used included the following:

1. Geographic:
   a. World Geodetic System (WGS84) and
   b. North American Datum (NAD) 1983
2. Projected:
   a. Albers Equal Area (regional projection for areas wider than tall),
   b. Lambert Conic Conformal (state resolution), and
   c. Universal Transverse Mercator (UTM). The eastern portion of the gopher tortoise range covers three UTM zones (15, 16, and 17).

GIS data layers collected with older projections were updated to WGS84 when possible. Metadata for all GIS data were reviewed and cataloged in ArcCatalog. Most data acquired were accompanied with sufficient metadata, but some data had incomplete metadata files. Any GIS data with missing metadata were updated with required metadata entries if available from the data source(s).

Additional data and ideas were gathered from review of previous research projects about the gopher tortoise and individual state wildlife conservation management plans.

4 Conclusion

The aim of this report was to document knowledge contained in the official record. It was not intended as a comment to any notable degree on the completeness or interpretation of those records. However, it did become self-evident that some of the data may be incomplete or misleading. Federal data sources appear to have little information beyond the scope of federal lands and likewise state data sources have little information beyond the scope of state lands. Two notable shortcomings related to the nature of the data appear to be somewhat misleading. One, some Mississippi and Alabama counties are not included that clearly are within the distribution of the tortoise but do not happen to have verified, recorded records for them. Two, many counties in South Carolina have records of one or two tortoises found on roadsides. These are believed, but not proven, to be captive animals illegally collected by vacationers in Florida and left behind during stops on their northward travels (pers. Comm. Stephen Bennett, South Carolina DNR). Thus, the actual range of permanent occupation in South Carolina is likely much less than that implied by the maps. These are just two examples of shortcomings found in the official record that illustrate a clear “gap” that needs updating and clarification. It is hoped that readers of this report who note other omissions will take the initiative to ensure that official records are updated accordingly.

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Appendix: Gopher Tortoise GIS Data Compilation Study

Table A1. GIS data organization.

Federal Data Sources	
	National Elevation Dataset
	Ecoregions
	Forests
	Census 2000 and Redistricting Census 2000 and Water Polygons
	GAP Analysis
	Geological
	Hydrological
	Land cover
	Military Installations
	MODIS Images
	Roads and Rails
	Soils
	Orthographic Images
State Data Sources	
Alabama	County Boundaries
	Hydrologic Units
	Alabama Topographic Map Index
Florida	Comprehensive Everglades Restoration Plan - Regions
	Ecological Greenways Network
	FL Natural Areas Inventory Conservation Areas Zone A
	FL Natural Areas Inventory Conservation Areas Zone B
	FL Natural Areas Inventory Conservation Areas Zone C
	FL Veg. and Land Cover FL Fish n Wildlife Conservation
	FL Wildlife Management Areas
	Florida Fish and Wildlife Conservation Commission Regional Boundaries
	Florida Forever Board Of Trustees Projects - January 2006
	Florida Managed Areas - March 2006
	Florida's Environmentally Sensitive Shorelines
	Habitat and Landcover_03
	Integrated Wildlife Habitat Ranking System
	National Parks and Seashores
	National Wildlife Refuges
	Physiographic Divisions Of Florida - Polygons
	Physiographic Provinces
	Public Lands - March 2006
	Strategic habitat conservation areas

	TNC Ecological Resource Conservation Areas
	usgs dem
Georgia	Dept of Defense Corps of Engineers
	Forest Service
	GA Dept of Natural Resources
	Local govt greenspace
	National Park Service
	NRCS
	Other Lands
	Rare species generalized locations
	State Land Conservation_GA Dept Transportation
	US Fish & Wildlife
Louisiana	managed_lands
	Natural_Hert_Prog
	Socioecon
Mississippi	maj_land_areas
	nat_parks
	phys_reg
	st_parks
	surface_geo
	wildlife_managed_area
	watersheds
South Carolina	Refuges
	Wetlands (Land Use and Land Cover)
University or Nongovernmental Organization	
George Mason University	Military Installations
The Nature Conservancy	Species Maps and Hydrological Units
University of Florida	Southeastern Ecological Framework
Jones Center	Gopher Tortoise Eastern Range Habitat Sites

Table A2. Counties (parishes) within eastern gopher tortoise range.

Alabama	Florida	Georgia	Louisiana	Mississippi	South Carolina
Baldwin	Charlotte	Baker	Washington	George	Aiken
Barbour	Citrus	Berrien		Greene	Allendale
Coffee	Collier	Bleckley		Harrison	Barnwell
Covington	Columbia	Brantley		Jackson	Beaufort
Dale	Desoto	Bulloch		Jones	Hampton
Escambia	Dixie	Burke		Lamar	Jasper
Geneva	Gilchrist	Calhoun		Marion	Orangeburg
Henry	Glades	Candler		Pearl River	
Houston	Hamilton	Chattahoochee		Perry	
	Hendry	Clay		Stone	
	Highlands	Coffee		Wayne	
	Hillsborough	Colquitt			
	Indian River	Cook			

Alabama	Florida	Georgia	Louisiana	Mississippi	South Carolina
	Lafayette	Crisp			
	Lake	Decatur			
	Lee	Dodge			
	Levy	Dooly			
	Manatee	Dougherty			
	Marion	Early			
	Martin	Emanuel			
	Miami_Dade	Evans			
	Monroe	Grady			
	Okaloosa	Houston			
	Orange	Jeff Davis			
	Osceola	Jenkins			
	Palm Beach	Laurens			
	Pasco	Lee			
	Pinellas	Liberty			
	Polk	Long			
	Sarasota	McIntosh			
	Seminole	Miller			
	St. John	Pierce			
	St. Lucie	Pulaski			
	Sumter	Quitman			
	Suwannee	Screven			
	Taylor	Seminole			
	Union	Stewart			
		Sumter			
		Tattnall			
		Telfair			
		Tift			
		Toombs			
		Treutlen			
		Ware			
		Worth			

Gopher tortoise data organized by state

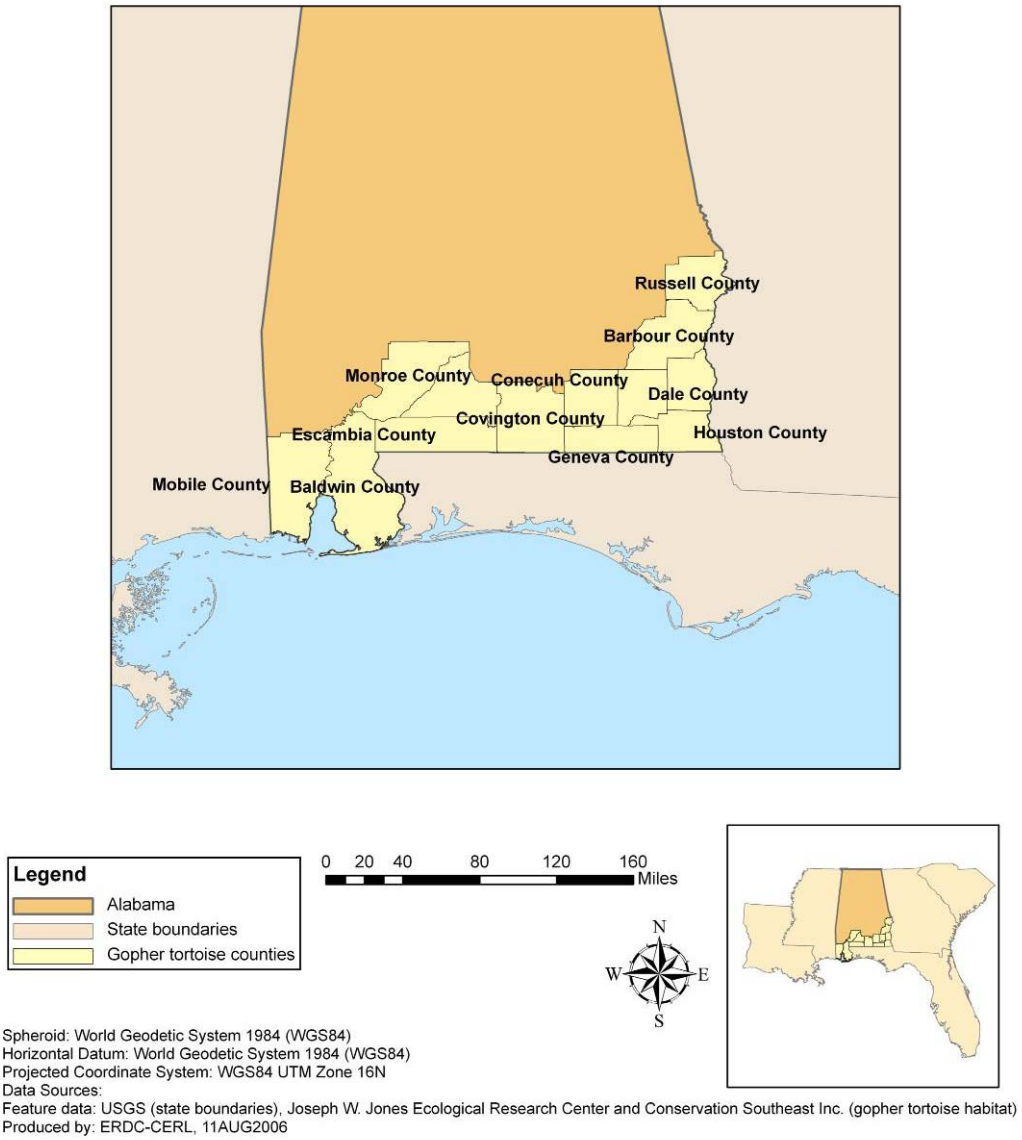

Figure A1. Gopher tortoise Alabama habitat map.

Table A3. Alabama geospatial data (Federal).

Data Type	Description	Source	Date Acquired
National Elevation Dataset	Seamless mosaic of best-available elevation data	U.S Geological Survey (USGS)	Apr.-May 2006
Ecoregions (Omernik's Level III and Bailey's)	Describe areas of general similarity in ecosystems and in the type, quality, and quantity of environmental resources	U.S Environmental Protection Agency (EPA)	Feb. 2006
Forests	Portrays general forest cover types for the United States	USDA Forest Service and USGS	Feb. 2006
GAP Analysis	Geospatial data layers documenting land cover, stewardship (ownership and management), vertebrate and invertebrate species habitat models, and species richness: all of which comprise the different GAP datasets.	National Biological Information Infrastructure and USGS	Mar.-Apr. 2006
Geological	Contains boundaries and tags for major geologic units, and depicts the geology of the bedrock that lies at or near the land surface, but not the distribution of surficial materials such as soils, alluvium, and glacial deposits	USGS	May 2006
Hydrological	Shows areal and linear water features	National Atlas of the United States	Feb. 2006
Land cover	Land cover characteristics	National Atlas of the United States	Feb. 2006
Military Installations	Contains the boundaries and location information for important military installations	Military Traffic Management Command Transportation Engineering Agency (MTMCTEA)	May 2006
MODIS Images	2005-2006 seasonal coarse spatial resolution images projected into a global coordinate system defined with pixel sizes corresponding to 20km in the Hammer-Aitoff projection	Goddard Space Flight Center, MODIS Land Science Team, MODIS Land Global Browse Images	May 2006
Railroads	Railroads in the conterminous United States	National Atlas of the United States	Feb. 2006
Roads	Portrays the major roads in the United States	National Atlas of the United States	Feb. 2006
Soils	Data set is a digital soil survey and generally is the most detailed level of soil geographic data developed by the National Cooperative Soil Survey	U.S. Department of Agriculture, Natural Resources Conservation Service (USDA, NRCS)	Jan.-Mar. 2006
Orthographic Images	Orthophotos combine the image characteristics of a photograph with the geometric qualities of a map. The primary digital orthophotoquad (DOQ) is a 1-meter ground resolution, quarter-quadrangle (3.75-minute of lati-	USDA, NRCS	Apr.-Jun. 2006

Data Type	Description	Source	Date Acquired
	tude and 3.75-minute of longitude) image cast on the Universal Transverse Mercator Projection (UTM) on the North American Datum of 1983 (NAD83).		

Table A4. Alabama geospatial data (state).

Data type	Description	Source	Date Acquired
County Boundaries	A dataset containing polygons representing each county in Alabama.	Geological Survey of Alabama	Apr. 2006
Hydrologic Units	A digital hydrologic unit boundary that is at the Watershed (11-digit) level for the State of Alabama	Geological Survey of Alabama	Apr. 2006
Alabama Topographic Map Index	Contains the polygon coverage of the USGS 7.5 minute Topographic Map Index	Geological Survey of Alabama	Apr. 2006

Table A5. Alabama geospatial data (university or NGO).

Data type	Description	Source	Date Acquired
(Jones Center) Gopher Tortoise Eastern Range Habitat Sites	Polygons and point data referencing Gopher Tortoise habitat throughout the eastern range	Jones Center, State Wildlife Management Agencies, and others	Feb. 2006
(University of Florida) Southeastern Ecological Framework	Integrates and connects existing conservation areas and currently unprotected areas of high ecological significance, and this information can be used in concert with other information on conservation priorities to develop a more integrated regional landscape protection strategy	GeoPlan Center, University of Florida	June 2006
The Nature Conservancy	Tabular data of U.S species maps	TNC	Apr. 2006

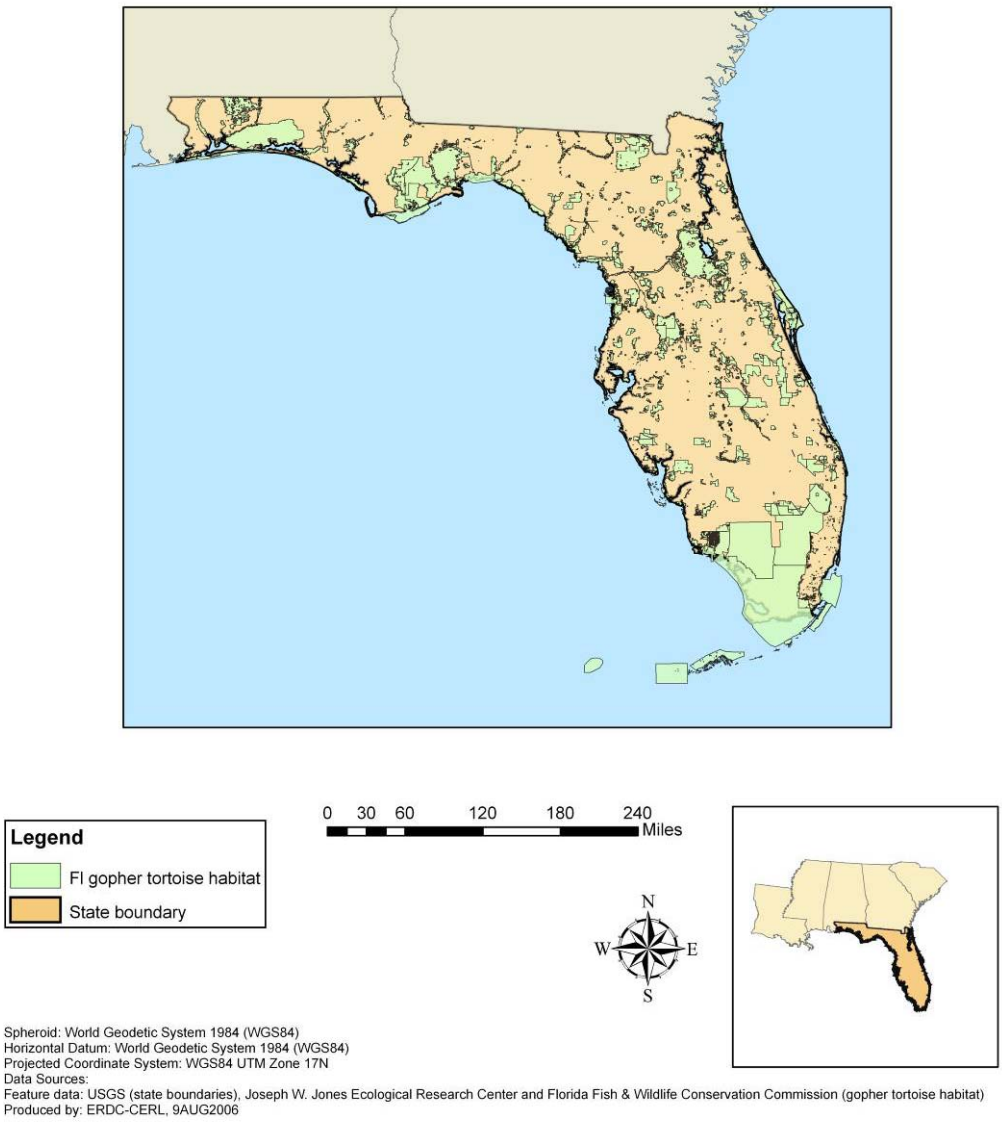

Figure A2. Gopher tortoise Florida habitat map.

Table A6. Florida geospatial data (Federal).

Data type: Federal	Description	Source	Date Acquired
National Elevation Dataset	Seamless mosaic of best-available elevation data	U.S Geological Survey (USGS)	Apr.-May 2006
Ecoregions (Omernik's Level III and Bailey's)	Describe areas of general similarity in ecosystems and in the type, quality, and quantity of environmental resources	U.S Environmental Protection Agency (EPA)	Feb. 2006
Forests	Portrays general forest cover types for the United States	USDA Forest Service and USGS	Feb. 2006

Data type: Federal	Description	Source	Date Acquired
GAP Analysis	Geospatial data layers documenting land cover, stewardship (ownership and management), vertebrate and invertebrate species habitat models, and species richness: all of which comprise the different GAP datasets.	National Biological Information Infrastructure and USGS	Mar.-Apr. 2006
Geological	Contains boundaries and tags for major geologic units, and depicts the geology of the bedrock that lies at or near the land surface, but not the distribution of surficial materials such as soils, alluvium, and glacial deposits	USGS	May 2006
Hydrological	Shows areal and linear water features	National Atlas of the United States	Feb. 2006
Land cover	Land cover characteristics	National Atlas of the United States	Feb. 2006
Military Installations	Contains the boundaries and location information for important military installations	Military Traffic Management Command Transportation Engineering Agency (MTMCTEA)	May 2006
MODIS Images	2005-2006 seasonal coarse spatial resolution images projected into a global coordinate system defined with pixel sizes corresponding to 20km in the Hammer-Aitoff projection	Goddard Space Flight Center, MODIS Land Science Team, MODIS Land Global Browse Images	May. 2006
Railroads	Railroads in the conterminous United States	National Atlas of the United States	Feb. 2006
Roads	Portrays the major roads in the United States	National Atlas of the United States	Feb. 2006
Soils	Data set is a digital soil survey and generally is the most detailed level of soil geographic data developed by the National Cooperative Soil Survey	U.S. Department of Agriculture, Natural Resources Conservation Service (USDA, NRCS)	Jan.-Mar. 2006
Orthographic Images	Orthophotos combine the image characteristics of a photograph with the geometric qualities of a map. The primary digital ortho-	USDA, NRCS	Apr.-June 2006

Data type: Federal	Description	Source	Date Acquired
	photoquad (DOQ) is a 1-meter ground resolution, quarter-quadrangle (3.75-minute of latitude and 3.75-minute of longitude) image cast on the Universal Transverse Mercator (UTM) Projection on the North American Datum of 1983 (NAD83).		

Table A7. Florida geospatial data (state).

Date Type: State	Description	Source	Date Acquired
Comprehensive Everglades Restoration Plan - Regions	Contains a boundary shapefile of the (CERP) Comprehensive Everglades Restoration Plan nine Regions. CERP is a framework and guide to restore, protect, and preserve the water resources of central and southern Florida, including the Everglades.	Florida Geographic Data Library (FGDL)	June 2006
Ecological Greenways Network	These priorities represent the most important areas for protecting large connected landscapes in Florida	University of Florida Geo-Plan Center	June 2006
FL Natural Areas Inventory Conservation Areas Zone A	Illustrates areas of conservation interest as categorized by the Florida Natural Areas Inventory (FNAI). The FNAI data are designed to provide information about significant natural resources for use by the Regional Planning Councils in preparing their Strategic Policy Plans. Areas of Conservation Interest (ACIs) are sites that support currently unprotected examples of important natural resources; the ACIs are delineated into three categories.	Florida Natural Areas Inventory	June 2006
FL Natural Areas Inventory Conservation Areas Zone B	Same as Zone A above	Same as Zone A above	June 2006
FL Natural Areas Inventory Conservation Areas Zone C	Same as Zone A above	Same as Zone A above	June 2006
FL Veg. and Land Cover FL Fish & Wildlife Conservation	Digital vegetation and land cover data set for Florida derived from 2003 Landsat Enhanced Thematic Mapper satellite imagery	Florida Fish and Wildlife Conservation Commission	June 2006
FL Wildlife Management Areas	Contains the management areas of the Florida Fish and Wildlife Conservation Commission	Florida Fish & Wildlife Conservation Commission	June 2006
Florida Fish and Wildlife Conservation Commission Regional Boundaries	Contains the region boundaries for the Florida Fish and Wildlife Conservation Commission	Florida Fish & Wildlife Conservation Commission	June 2006
Florida Forever	Polygon data layer for Florida Forever Board	Florida Natu-	June

Date Type: State	Description	Source	Date Acquired
Board Of Trustees Projects - January 2006	of Trustees (BOT) projects (formerly known as CARL projects). This data layer is site-based and contains boundaries of all Florida Forever BOT projects approved by the State's Acquisition and Restoration Council as of 9 December 2005.	ral Areas Inventory (FNAI)	2006
Florida Managed Areas - March 2006	Polygon data layer for public (and some private) lands that the Florida Natural Areas Inventory (FNAI) has identified as having natural resource value and that are being managed at least partially for conservation purposes.	Florida Natural Areas Inventory (FNAI)	June 2006
Florida's Environmentally Sensitive Shorelines	Contains the locations and descriptions of Florida's environmentally sensitive shorelines	Florida Marine Research Institute	June 2006
Habitat and Landcover_03	Contains plant community and landcover data for the State of Florida	Florida Geographic Data Library	June 2006
Integrated Wildlife Habitat Ranking System	Contains the final model results from the Integrated Wildlife Habitat Ranking System, a process for identification and ranking of landscape level habitat areas which are important to a broad array of wildlife species.	Florida Fish and Wildlife Conservation Commission	June 2006
National Parks and Seashores	Contains National Park and Seashore Service boundaries in the state of Florida	NOAA Coastal Services Center OPIS	June 2006
National Wildlife Refuges	Contains the spatial boundaries of National Wildlife Refuges in Florida	National Oceanic and Atmospheric Administration (NOAA) Coastal Services Center (CSC)	June 2006
Physiographic Divisions Of Florida - Polygons	Contains the locations and names of physiographic units as defined by Dr. H.K. Brooks's "Physiographic Divisions of Florida" map and its accompanying guide	St. Johns River Water Management District	June 2006
Physiographic Provinces	Contains the physiographic provinces of Florida	Florida Department of Environmental Protection	June 2006
Public Lands - March 2006	Contains all FLORIDA MANAGED AREAS (FNAI layer name FLMA) that are managed by the State, Local, or Federal government (note: some of these lands may be owned by Private Individual(s))	Florida Natural Areas Inventory	June 2006
strategic habitat conservation areas	Contains proposed lands for conservation management that are necessary to protect viable populations of 44 focal wildlife species and other analyzed elements of biological di-	Florida Fish & Wildlife Conservation Commission	June 2006

Date Type: State	Description	Source	Date Acquired
	versity that include rare plants, rare biological communities, and wetlands important for wading birds		
TNC Ecological Resource Conservation Areas	Contains priority ecological resource areas as identified by the workshop of January 1991 sponsored by The Nature Conservancy, Florida Audubon Society and the Department of Natural Resources	Florida Natural Areas Inventory	June 2006
usgs dem	Contains a Digital Elevation Model (DEM)	USGS	June 2006

Table A8. Florida geospatial data (university or NGO).

Data Type: University or NGO	Description	Source	Date Acquired
(Jones Center) Gopher Tortoise Eastern Range Habitat Sites	Polygons and point data referencing Gopher Tortoise habitat throughout the eastern range	Jones Center, State Wildlife Management Agencies, and others	Feb. 2006
(University of Florida) Southeastern Ecological Framework	Integrates and connects existing conservation areas and currently unprotected areas of high ecological significance, and this information can be used in concert with other information on conservation priorities to develop a more integrated regional landscape protection strategy	GeoPlan Center, University of Florida	June 2006
The Nature Conservancy (TNC)	Tabular data of U.S species maps	TNC	Apr. 2006

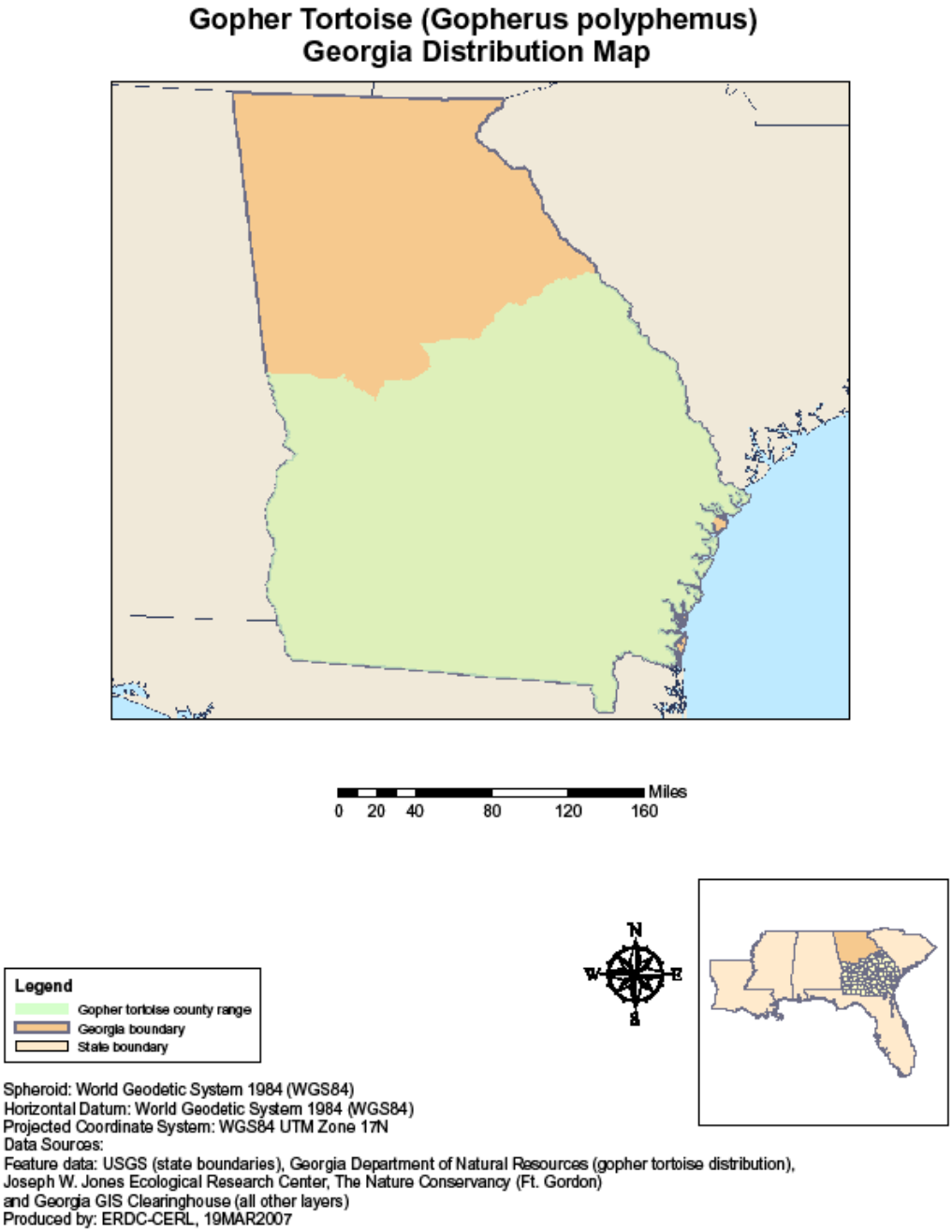

Figure A3. Gopher tortoise Georgia habitat map.

Table A9. Georgia geospatial data (Federal).

Data Type: Federal	Description	Source	Date Acquired
National Elevation Dataset	Seamless mosaic of best-available elevation data	U.S Geological Survey (USGS)	Apr.-May 2006
Ecoregions (Omernik's Level	Describe areas of general similarity in ecosystems and in the type, quality, and	U.S Environmental Protection Agency	Feb. 2006

Data Type: Federal	Description	Source	Date Acquired
III and Bailey's)	quantity of environmental resources	(EPA)	
Forests	Portrays general forest cover types for the United States	USDA Forest Service and USGS	Feb. 2006
GAP Analysis	Geospatial data layers documenting land cover, stewardship (ownership and management), vertebrate and invertebrate species habitat models, and species richness: all of which comprise the different GAP datasets.	National Biological Information Infrastructure and USGS	Mar.-Apr. 2006
Geological	Contains boundaries and tags for major geologic units, and depicts the geology of the bedrock that lies at or near the land surface, but not the distribution of surficial materials such as soils, alluvium, and glacial deposits	USGS	May 2006
Hydrological	Shows areal and linear water features	National Atlas of the United States	Feb. 2006
Land cover	Land cover characteristics	National Atlas of the United States	Feb. 2006
Military Installations	Contains the boundaries and location information for important military installations	Military Traffic Management Command Transportation Engineering Agency (MTMCTEA)	May 2006
MODIS Images	2005-2006 seasonal coarse spatial resolution images projected into a global coordinate system defined with pixel sizes corresponding to 20km in the Hammer-Aitoff projection	Goddard Space Flight Center, MODIS Land Science Team, MODIS Land Global Browse Images	May 2006
Railroads	Railroads in the conterminous United States	National Atlas of the United States	Feb. 2006
Roads	Portrays the major roads in the United States	National Atlas of the United States	Feb. 2006
Soils	Data set is a digital soil survey and generally is the most detailed level of soil geographic data developed by the National Cooperative Soil Survey	U.S. Department of Agriculture, Natural Resources Conservation Service (USDA, NRCS)	Jan.-Mar. 2006
Orthographic Images	Orthophotos combine the image characteristics of a photograph with the geometric qualities of a map. The primary digital orthophotoquad (DOQ) is a 1-meter ground resolution, quarter-quadrangle (3.75-minute of latitude and 3.75-minute of longitude) image cast on the Universal Transverse Mercator (UTM) Projection on the North American Datum of 1983 (NAD83).	USDA, NRCS	Apr.-June 2006

Table A10. Georgia geospatial data (state).

Data Type: State	Description	Source	Date Acquired
Conservation Lands	A product of the Georgia GAP Analysis Project compiled for statewide comparison of the distribution of lands managed for protection of biodiversity with potential habitat of vertebrates present in the state	Natural Resource Spatial Analysis Laboratory (NARSAL), Institute of Ecology, University of Georgia (UGA)	June 2006
Dept of Defense Corps of Engineers	Dataset provides 1:24,000-scale data depicting boundaries of land parcels making up the lands managed by the Department of Defense in Georgia	Georgia Natural Heritage Program	June 2006
Forest Service	Dataset provides 1:24,000-scale data depicting boundaries of land parcels making up the public lands managed by the US Forest Service in Georgia	Georgia Natural Heritage Program	June 2006
GA Dept of Natural Resources	Dataset provides 1:24,000-scale data depicting boundaries of land parcels making up the public lands managed by the Georgia Department of Natural Resources (GDNR). It includes polygon representations of State Parks, State Historic Parks, State Conservation Parks, State Historic Sites, Wildlife Management Areas, Public Fishing Areas, Fish Hatcheries, Natural Areas and other specially-designated areas.	Georgia Natural Heritage Program	June 2006
National Park Service	Dataset provides 1:24,000-scale data depicting boundaries of land parcels making up the public lands managed by the National Park Service in Georgia.	Georgia Natural Heritage Program	June 2006
NRCS	Dataset provides 1:24,000-scale data depicting boundaries of land parcels making up the lands managed by the Natural Resource Conservation Service in Georgia	Georgia Natural Heritage Program	June 2006
Other Lands	TNC coverage boundaries, BOR is a subset of lands owned by the University System, GA. Greenspaces conservation lands, GA. DOT lands (wetland mitigation), and GWTF (more conservation lands)	Georgia Natural Heritage Program	June 2006
Rare species generalized locations	NA	Georgia Natural Heritage Program	June 2006
State Land Conservation GA Dept Transportation	Dataset provides 1:24,000-scale data depicting boundaries of land parcels making up the wetland mitigation lands managed by the Georgia Department of Transportation (GDOT)	Georgia Natural Heritage Program	June 2006
US Fish & Wildlife	Dataset provides 1:24,000-scale data depicting boundaries of land parcels making up the public lands managed by the US Fish and Wildlife Service in Georgia	Georgia Natural Heritage Program	June 2006

Table A11. Georgia geospatial data (university or NGO).

Data Type: University or NGO	**Description**	**Source**	**Date Acquired**
(Jones Center) Gopher Tortoise Eastern Range Habitat Sites	Polygons and point data referencing Gopher Tortoise habitat throughout the eastern range	Jones Center, State Wildlife Management Agencies, and others	Feb. 2006
(University of Florida) Southeastern Ecological Framework	Integrates and connects existing conservation areas and currently unprotected areas of high ecological significance, and this information can be used in concert with other information on conservation priorities to develop a more integrated regional landscape protection strategy	GeoPlan Center, University of Florida	June 2006
The Nature Conservancy (TNC)	Tabular data of U.S. species maps	TNC	Apr. 2006

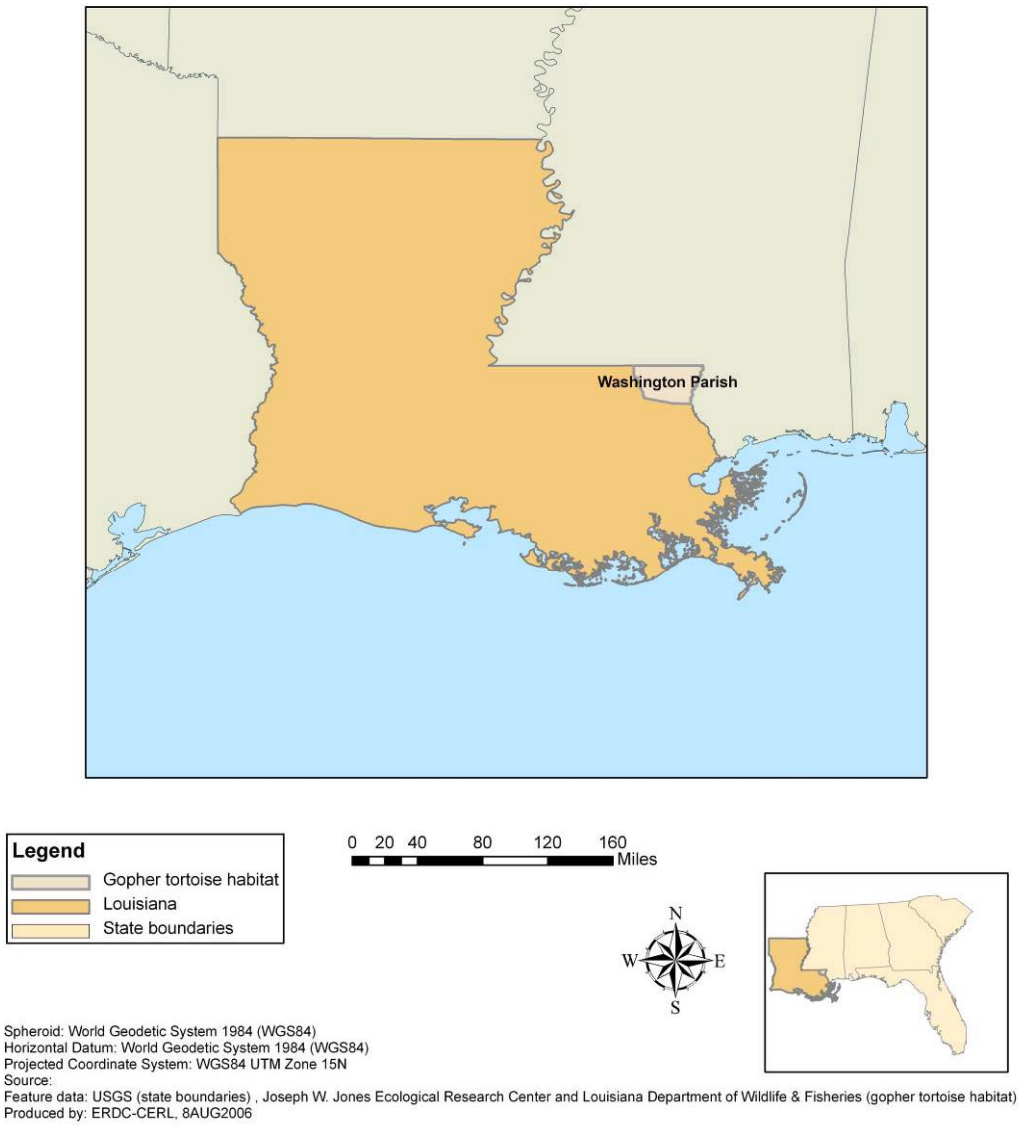

Figure A4. Gopher tortoise Louisiana habitat map.

Table A12. Louisiana geospatial data (Federal).

Data Type: Federal	Description	Source	Date Acquired
National Elevation Dataset	Seamless mosaic of best-available elevation data	U.S. Geological Survey (USGS)	Apr.-May 2006
Ecoregions (Omernik's Level III and Bailey's)	Describe areas of general similarity in ecosystems and in the type, quality, and quantity of environmental resources	U.S. Environmental Protection Agency (EPA)	Feb. 2006
Forests	Portrays general forest cover types for the United States	USDA Forest Service and USGS	Feb. 2006
GAP Analysis	Geospatial data layers documenting land cover, stewardship (ownership and	National Biological Information	Mar.-Apr. 2006

Data Type: Federal	Description	Source	Date Acquired
	management), vertebrate and invertebrate species habitat models, and species richness: all of which comprise the different GAP datasets.	Infrastructure and USGS	
Geological	Contains boundaries and tags for major geologic units, and depicts the geology of the bedrock that lies at or near the land surface, but not the distribution of surficial materials such as soils, alluvium, and glacial deposits	USGS	May 2006
Hydrological	Shows areal and linear water features	National Atlas of the United States	Feb. 2006
Land cover	Land cover characteristics	National Atlas of the United States	Feb. 2006
Military Installations	Contains the boundaries and location information for important military installations	Military Traffic Management Command Transportation Engineering Agency (MTMCTEA)	May 2006
MODIS Images	2005-2006 seasonal coarse spatial resolution images projected into a global coordinate system defined with pixel sizes corresponding to 20km in the Hammer-Aitoff projection	Goddard Space Flight Center, MODIS Land Science Team, MODIS Land Global Browse Images	May 2006
Railroads	Railroads in the conterminous United States	National Atlas of the United States	Feb. 2006
Roads	Portrays the major roads in the United States	National Atlas of the United States	Feb. 2006
Soils	Data set is a digital soil survey and generally is the most detailed level of soil geographic data developed by the National Cooperative Soil Survey	U.S. Department of Agriculture, Natural Resources Conservation Service (USDA, NRCS)	Jan.-Mar. 2006
Orthographic Images	Orthophotos combine the image characteristics of a photograph with the geometric qualities of a map. The primary digital orthophotoquad (DOQ) is a 1-meter ground resolution, quarter-quadrangle (3.75-minute of latitude and 3.75-minute of longitude) image cast on the Universal Transverse Mercator (UTM) Projection on the North American Datum of 1983 (NAD83).	USDA, NRCS	Apr.-June 2006

Table A13. Louisiana data (state).

Data Type: State	Description	Source	Date Acquired
Managed lands	Data set contains boundaries for managed lands in coastal Louisiana	Minerals Management Service (MMS), Louisiana State University (LSU), Center for Coastal, Energy and Environmental Resources (CCEER) and the Department of Geography and Anthropology, Louisiana Department of Wildlife and Fisheries (LDWF), and Research Planning, Inc. (RPI)	May 2006
Natural Heritage Program	Data set contains sensitive biological resource data developed from the Louisiana National Heritage Program (NHP) database for coastal Louisiana	MMS, LSU, CCEER, LDWF, RPI	May 2006
Socioeconomic	Data set contains socio-economic features in coastal Louisiana	MMS, LSU, CCEER, LDWF, RPI	May 2006

Table A14. Louisiana geospatial data (university or NGO).

Data Type: University or NGO	Description	Source	Date Acquired
(Jones Center) Gopher Tortoise Eastern Range Habitat Sites	Polygons and point data referencing Gopher Tortoise habitat throughout the eastern range	Jones Center, State Wildlife Management Agencies, and others	Feb. 2006
(University of Florida) Southeastern Ecological Framework	Integrates and connects existing conservation areas and currently unprotected areas of high ecological significance, and this information can be used in concert with other information on conservation priorities to develop a more integrated regional landscape protection strategy	GeoPlan Center, University of Florida	June 2006
The Nature Conservancy (TNC)	Tabular data of U.S. species maps	TNC	Apr. 2006

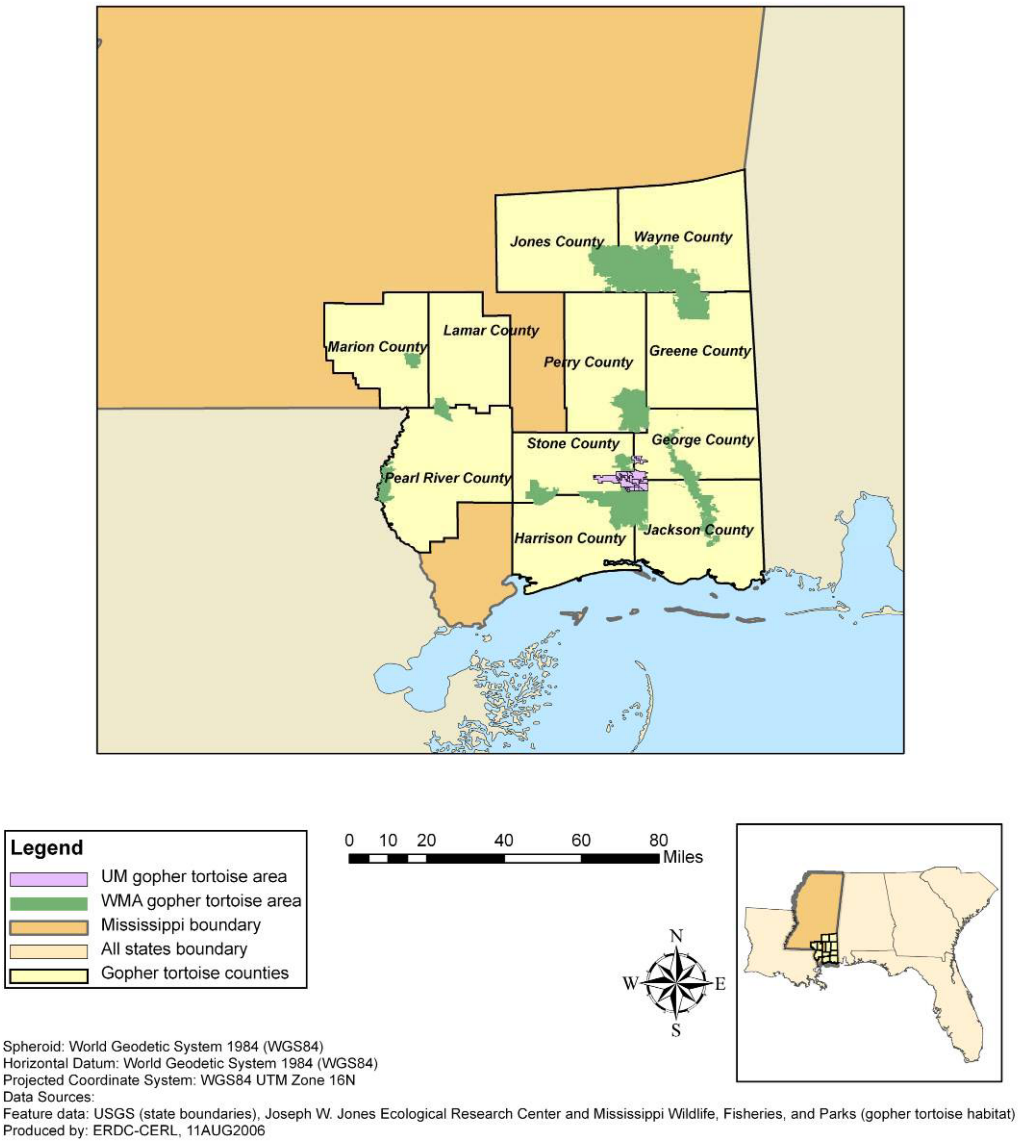

Figure A5. Gopher tortoise Mississippi habitat map.

Table A15. Mississippi geospatial data (Federal).

Data Type: Federal	Description	Source	Date Acquired
National Elevation Dataset	Seamless mosaic of best-available elevation data	U.S. Geological Survey (USGS)	Apr.-May 2006
Ecoregions (Omernik's Level III and Bailey's)	Describe areas of general similarity in ecosystems and in the type, quality, and quantity of environmental resources	U.S. Environmental Protection Agency (EPA)	Feb. 2006
Forests	Portrays general forest cover types for the United States	USDA Forest Service and USGS	Feb. 2006
GAP Analysis	Geospatial data layers documenting	National Biological	Mar.-Apr.

Data Type: Federal	Description	Source	Date Acquired
	land cover, stewardship (ownership and management), vertebrate and invertebrate species habitat models, and species richness: all of which comprise the different GAP datasets.	Information Infrastructure and USGS	2006
Geological	Contains boundaries and tags for major geologic units, and depicts the geology of the bedrock that lies at or near the land surface, but not the distribution of surficial materials such as soils, alluvium, and glacial deposits	USGS	May. 2006
Hydrological	Shows areal and linear water features	National Atlas of the United States	Feb. 2006
Land cover	Land cover characteristics	National Atlas of the United States	Feb. 2006
Military Installations	Contains the boundaries and location information for important military installations	Military Traffic Management Command Transportation Engineering Agency (MTMCTEA)	May. 2006
MODIS Images	2005-2006 seasonal coarse spatial resolution images projected into a global coordinate system defined with pixel sizes corresponding to 20km in the Hammer-Aitoff projection	Goddard Space Flight Center, MODIS Land Science Team, MODIS Land Global Browse Images	May. 2006
Railroads	Railroads in the conterminous United States	National Atlas of the United States	Feb. 2006
Roads	Portrays the major roads in the United States	National Atlas of the United States	Feb. 2006
Soils	Data set is a digital soil survey and generally is the most detailed level of soil geographic data developed by the National Cooperative Soil Survey	U.S. Department of Agriculture, Natural Resources Conservation Service (USDA, NRCS)	Jan.-Mar. 2006
Orthographic Images	Orthophotos combine the image characteristics of a photograph with the geometric qualities of a map. The primary digital orthophotoquad (DOQ) is a 1-meter ground resolution, quarter-quadrangle (3.75-minute of latitude and 3.75-minute of longitude) image cast on the Universal Transverse Mercator Projection (UTM) on the North American Datum of 1983 (NAD83).	USDA, NRCS	Apr.-June 2006

Table A16. Mississippi geospatial data (state).

Data Type: State	Description	Source	Date Acquired
Major land areas	Boundaries of major land resource areas	USDA Soil Conservation Service	May. 2006
MISS forest habitat	Major forest habitat regions	MSU / Auburn Joint Effort	Jul. 2006
National forests	Boundaries of proclamation areas of each national forest in Mississippi	U.S. Forest Service	Jul. 2006
National parks	Boundaries of National Parks in Mississippi	USGS	May 2006
Physiographic region	Physiographic regions	MARIS Technical Center	May 2006
State parks	Boundaries of State Parks in Mississippi	MS Dept. of Wildlife, Fisheries, & Parks	May 2006
Surface geology	Surface geologic formations	MS Dept. of Environmental Quality - Office of Geology	May 2006
Wildlife managed area	Wildlife Management Area boundaries	MS Dept. of Wildlife Fisheries & Parks	May 2006
Watersheds	Watershed boundaries as determined by the U.S. Soil Conservation Service	U.S. Soil Conservation Service, Dept. of Environmental Quality, MARIS Technical Center	May 2006

Table A17. Mississippi geospatial data (university or NGO).

Data Type: University or NGO	Description	Source	Date Acquired
(Jones Center) Gopher Tortoise Eastern Range Habitat Sites	Polygons and point data referencing Gopher Tortoise habitat throughout the eastern range	Jones Center, State Wildlife Management Agencies, and others	Feb. 2006
(University of Florida) Southeastern Ecological Framework	Integrates and connects existing conservation areas and currently unprotected areas of high ecological significance, and this information can be used in concert with other information on conservation priorities to develop a more integrated regional landscape protection strategy	GeoPlan Center, University of Florida	June 2006
The Nature Conservancy (TNC)	Tabular data of U.S. species maps	TNC	Apr. 2006

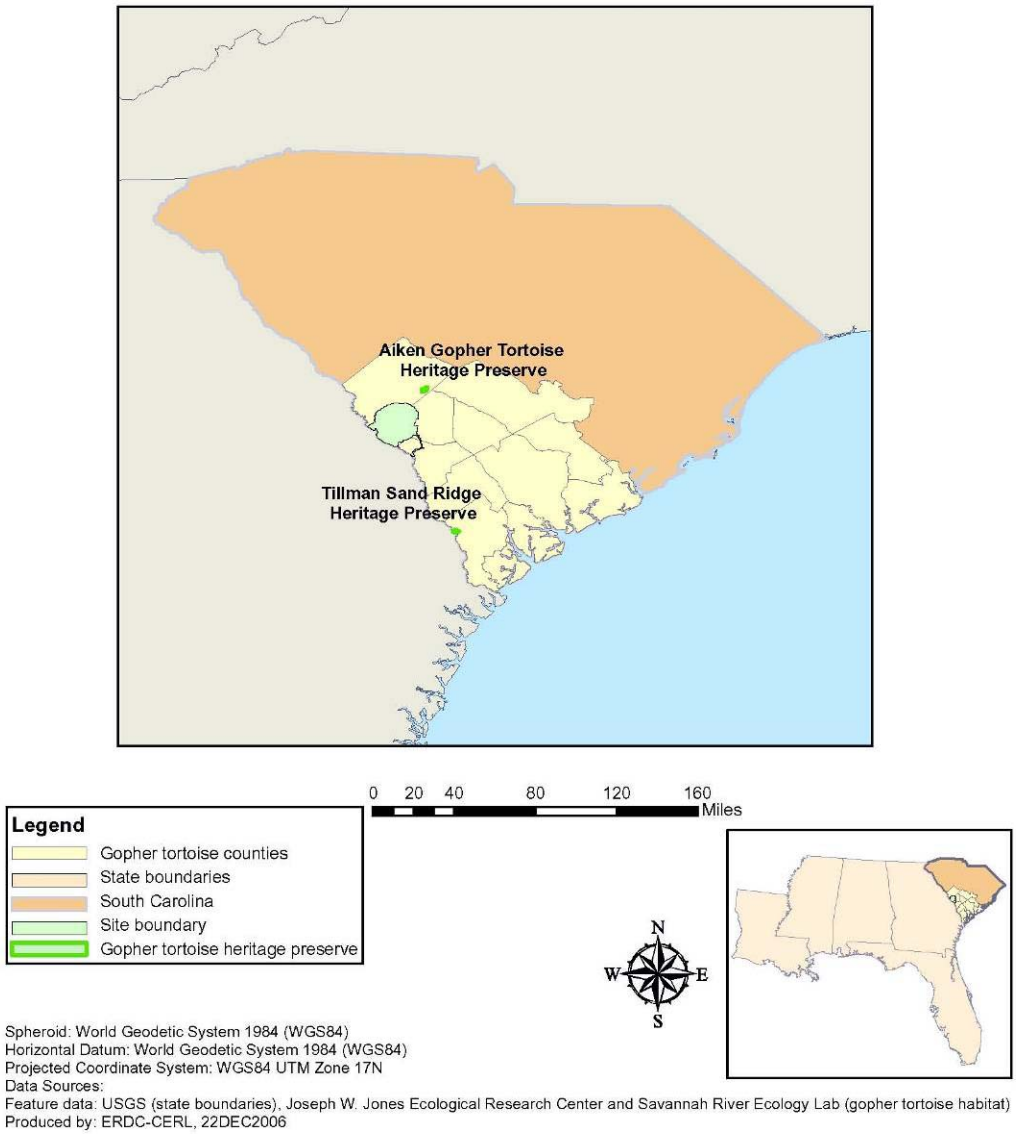

Figure A6. Gopher tortoise South Carolina habitat map.

Table A18. South Carolina geospatial data (Federal).

Data Type: Federal	Description	Source	Date Acquired
National Elevation Dataset	Seamless mosaic of best-available elevation data	U.S. Geological Survey (USGS)	Apr.-May 2006
Ecoregions (Omernik's Level III and Bailey's)	Describe areas of general similarity in ecosystems and in the type, quality, and quantity of environmental resources	U.S. Environmental Protection Agency (EPA)	Feb. 2006
Forests	Portrays general forest cover types for the United States	USDA Forest Service and USGS	Feb. 2006
GAP Analysis	Geospatial data layers documenting land cover, stewardship (ownership and management), vertebrate and	National Biological Information Infrastructure and USGS	Mar.-Apr. 2006

Data Type: Federal	Description	Source	Date Acquired
	invertebrate species habitat models, and species richness: all of which comprise the different GAP datasets.		
Geological	Contains boundaries and tags for major geologic units, and depicts the geology of the bedrock that lies at or near the land surface, but not the distribution of surficial materials such as soils, alluvium, and glacial deposits	USGS	May. 2006
Hydrological	Shows areal and linear water features	National Atlas of the United States	Feb. 2006
Land cover	Land cover characteristics	National Atlas of the United States	Feb. 2006
Military Installations	Contains the boundaries and location information for important military installations	Military Traffic Management Command Transportation Engineering Agency (MTMCTEA)	May. 2006
MODIS Images	2005-2006 seasonal coarse spatial resolution images projected into a global coordinate system defined with pixel sizes corresponding to 20km in the Hammer-Aitoff projection	Goddard Space Flight Center, MODIS Land Science Team, MODIS Land Global Browse Images	May. 2006
Railroads	Railroads in the conterminous United States	National Atlas of the United States	Feb. 2006
Roads	Portrays the major roads in the United States	National Atlas of the United States	Feb. 2006
Soils	Data set is a digital soil survey and generally is the most detailed level of soil geographic data developed by the National Cooperative Soil Survey	U.S. Department of Agriculture, Natural Resources Conservation Service (USDA, NRCS)	Jan.-Mar. 2006
Orthographic Images	Orthophotos combine the image characteristics of a photograph with the geometric qualities of a map. The primary digital orthophotoquad (DOQ) is a 1-meter ground resolution, quarter-quadrangle (3.75-minute of latitude and 3.75-minute of longitude) image cast on the Universal Transverse Mercator (UTM) Projection on the North American Datum of 1983 (NAD83).	USDA, NRCS	Apr.-June 2006

Table A19. South Carolina geospatial data (state).

Data Type: State	Description	Source	Date Acquired
Refuges	Digital line graph (DLG) data are digital representations of cartographic information. DLGs of map features are converted to digital form from maps and related sources.	South Carolina Department of Natural Resources GIS Data Clearinghouse	May 2006
Wetlands (Land Use and Land Cover)	NWI digital data files are records of wetlands location and classification as defined by the U.S. Fish & Wildlife Service.	USGS and South Carolina Department of Natural Resources GIS Data Clearinghouse	May 2006
Wildlife management area	Digital line graph (DLG) data are digital representations of cartographic information. DLGs of map features are converted to digital form from maps and related sources.	South Carolina Department of Natural Resources GIS Data Clearinghouse	Nov. 2006
Aiken Gopher Tortoise Preserve	2002 burrow survey data	Tracey Tuberville, Savannah River Ecology Laboratory	Mar. 2007
Public Service Authority, Jasper County	Located a couple of kilometers from the Tillman Sand Ridge Preserve. Borrow survey data based on burrow use with telemetered tortoises.	Tracey Tuberville, Savannah River Ecology Laboratory	Mar. 2007
Savannah River Site, Aiken	2001-2002 burrow survey of tortoises translocated to Savannah River Site from an industrial site in southeast GA. 800 series are starter burrows. 900 series burrows are adult or subadult created by released tortoises.	Tracey Tuberville, Savannah River Ecology Laboratory	Mar. 2007
Tillman Sand Ridge Preserve	2000-2004 burrow data based mainly on telemetered tortoises and their burrows	Tracey Tuberville, Savannah River Ecology Laboratory	Mar. 2007
Tillman Sand Ridge Preserve	Late 1990's burrow survey of large section of the preserve	Tracey Tuberville, Savannah River Ecology Laboratory	Mar. 2007

Table A20. South Carolina geospatial data (university or NGO).

Data Type: University or NGO	Description	Source	Date Acquired
(Jones Center) Gopher Tortoise Eastern Range Habitat Sites	Polygons and point data referencing Gopher Tortoise habitat throughout the eastern range	Jones Center, State Wildlife Management Agencies, and others	Feb. 2006
(University of Florida) Southeastern Ecological Framework	Integrates and connects existing conservation areas and currently unprotected areas of high ecological significance, and this information can be used in concert with other information on conservation priorities to develop a more integrated regional landscape protection strategy	GeoPlan Center, University of Florida	June 2006
The Nature Conservancy (TNC)	Tabular data of U.S. species maps	TNC	Apr. 2006

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE (DD-MM-YYYY)	2. REPORT TYPE	3. DATES COVERED (From - To)
05-2007	Final	

4. TITLE AND SUBTITLE
Existing Geospatial Knowledge of Gopher Tortoise Population and Abundance

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)
William D. Meyer, Harold E. Balbach, and Jason T. Berner

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
U.S. Army Engineer Research and Development Center (ERDC)
Construction Engineering Research Laboratory (CERL)
PO Box 9005
Champaign, IL 61826-9005

8. PERFORMING ORGANIZATION REPORT NUMBER
ERDC/CERL SR-07-5

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)
U.S. Army Corps of Engineers
441 G Street NW
Washington, DC 20314-1000

10. SPONSOR/MONITOR'S ACRONYM(S)

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION / AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited.

13. SUPPLEMENTARY NOTES

14. ABSTRACT

A number of key Army installations in the southeastern United States support numerous at-risk species. Many of these species have the potential to cause severe training restrictions in the future. To avoid the loss of training capacity, a proactive strategy for species conservation across the range must be developed.

The gopher tortoise (*Gopherus polyphemus*) may be the most prominent and most widely distributed of these at-risk species in the Southeast. In the case of the tortoise, a proactive strategy will require a basic understanding of its current abundance and distribution, better understanding of its habitat requirements, development of population viability analysis methods, agreement among regulators and land managers on population goals, and methods to efficiently monitor gopher tortoise populations over time with regard to the established population goals.

Data on the gopher tortoise were collected from academic, national, state, and local sources. All data were captured in tabular or GIS vector and raster formats. Data received at the Construction Engineering Research Laboratory were entered into spatial data layers as appropriate, and appended with quality-checked metadata to describe the dataset. This dataset will be available on CD or DVD for distribution to the public.

15. SUBJECT TERMS
Gopher tortoise
Geographic information systems (GIS)
military training
natural resource management
threatened and endangered species

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			19b. TELEPHONE NUMBER (include area code)
Unclassified	Unclassified	Unclassified	SAR	44	